MEMORY FOR LIFTED WEIGHTS.

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The object of the investigation was two-fold; on the one hand to study the influence of the interval upon the accuracy and quickness of recognition, and on the other to determine the mental processes involved in comparison and recognition. Lifted weights were used because they promised a domain where memorial images are very weak and would therefore shed light upon the place of the memorial image in recognition or comparison.

The results have, in a measure, at least, justified the expectation. As the historical side of the question has been pretty thoroughly covered in various articles, it seems advisable to omit in this connection further discussion of that, and to proceed at once to a description of the experiments, and an analysis of the data thus obtained. The experiments reported in this paper were begun in the fall of 1903 and continued without interruption until the middle of June of the following year.

EXPERIMENTAL.

The reaction times of the subjects were taken by means of a Hipp chronoscope, giving, on the average, readings which were correct to within 1.9σ. The subject was seated at a desk of convenient height, so that the right forearm rested comfortably upon it. The back of the hand rested upon a reaction key, which with a lip-key was used in the earlier experiments; but as it was found to be in many ways inconvenient, a Cattell speech key as modified by Walt was substituted and gave complete satisfaction. When the reagent lifted his hand from the reacting key, the circuit was completed through the chronoscope; and when he announced his judgment by speaking into the tube, the vibration of the disk broke the circuit, and in this way the total reaction-time was registered. The amount of flexion of the arm was regulated by a padded bar placed at a suitable height above the table, so that in lifting the weight, the wrist touched the bar.

A determination of the time taken in lifting the weights was made from time to time to see how constant its value was in the case of the different reagents: the mean variations range from 3% to 8% for the different subjects. When we compare these figures with the mean variations for the recognition-times

reported in the tables, it is evident that the control of lifting was relatively rigorous.

A series of eight Jastrow weights were used, ranging from a few grammes (20) up to a heavy weight of 600 grammes. Two of these, one of 250 gms. and the other of 225 gms. were kept constant thoughout the experiment, and furnished the weight intervals given in the tables. The weights were identical in shape and size consisting of hollow hard rubber cylinders, 4 inches long and 2 inches in diameter, which could be filled with a variable amount of shot kept from rattling by pads. The weights were kept out sight of the reagents by means of small screens, so that they remained in ignorance of the number of weights used. The "now" was given two seconds before the weight was placed by the experimenter in the hands of the reagent for lifting, and the time between the lifting of the norm and the stimulus of comparison was regulated by a stop-watch graduated to one-fifth of a second. The first weight lifted was taken as the norm, and the second weight as the stimulus, which was reported by the reagent to be "lighter," "equal," or "heavier" than the norm. For the standard intervals, the order of presenting the weights was reversed sometime during the experiment, as is the customary procedure to avoid constant errors. To reduce habituation to a minimum, the weights compared were chosen in irregular order; that is to say, the standard intervals which give the reaction times of the tables were interpolated between several other intervals. Calling the weights A, B, C, D, E, F, G, H, of which D and F, we will suppose, are the standards, we would have something like the following combinations in a typical experiment: B-C, *D-F*, G-H, *D-D*, *F-F*, C-H, *F-D*, *F-F*, etc.

The reagent, at the end of each comparison, gave an introspective account, as best he could, of the process of judgment. With some of the less experienced reagents, these reports were at first rather vague and confused; but soon each developed a terminology of his own that greatly abridged the task of recording the introspections. Out of this grew the classification of judgments used in table III. The reagents reported cases in which the norm and stimulus of comparison, were distinctly placed in a scale of values, or in which only one was thus carefully classified, with littlc or no reproduction of the sensations occasioned by the lifting of the norm. Here, of course, if any reliance is to be placed upon introspection, the central process is largely one of verbal supplementation. Other cases occurred in which the stimulus of comparison did not seem to have an absolute position assigned to it in the scale of weight values, but yet did have a position relative to the absolute position of the first. Both have been treated together in the tables under

the head of absolute judgments. In another class of judgments, along with the verbal supplementation, went a considerable amount of memorial image representation, in which the reagents assigned about equal importance to the two processes in the comparison of norm and stimulus. (It should be noted in passing that although the judgment in lifted weights is primarily directed to strain sensation, other sensations, in particular, visual, are integral parts of the mental activities involved, and with one exception, Mr. Freund, the visual memory of the arm movement was more predominant than the memory of the strain and pressure sensations.) Judgments of this type are reported as "mixed." In other instances, verbal supplementation played an insignificant rôle; the memory image in some form (visual, of arm movement, or motile, of pressure and strain) seemed clear enough to mediate comparison; such are recorded as "direct." One subject (Mr. Wright) furnishes a few judgments, sixteen, in which neither verbal supplementation nor the reproduction of memorial images was noticeable. The writer is inclined to regard these as of a negative character, due to inadequate or hasty introspection on the part of the reagent. They have been given a place as the fourth type of judgment under the denomination of "immediate."

The time intervals chosen for record were 20 secs., 30 secs. 40 secs., 50 secs., 60 secs., 80 secs., 100 secs., 120 secs. At first shorter intervals of 5 secs., and 10 secs. were used; but these were found on trial to be too short to permit the experimenter to perform his share of the work without some confusion and embarrassment. Now and then a longer time interval was interpolated, either in a blank experiment or in one desired for the introspective account. Each subject filled in the time between presentation of norm and stimulus with such mental occupation as he pleased.

Five subjects took part in the investigation: Dr. Pillsbury (P.), Mr. Galloway (G.), Mr. Wright (W.), Mr. Sherman (S.), Mr. Freund (F.) All except the last had had considerable training in laboratory work, the last, one semester's work in an introductory course.

Analysis of the Tables.

A. The Effect of the Memory Interval on the Time of Recognition. In the table below are given the average reaction times of all judgments taken together for the different intervals of time and for the whole eight intervals considered as a unit:

An inspection of the table fails to reveal the existence of a factor whose influence can be expressed in the definite mathematical fashion in which has been presented the time-course of the dissolution of a memorial image. We find for $\Delta = \pm 25$

TABLE I.

Average reaction times (r.t.), for the various memory intervals (t.i.), for the weight difference (△) of 25 ± gm and 0 gm, both right and wrong judgments taken together.

t. i.	20s.	30s.	40s.	50s.	60s.	80s.	100s.	120s.	Av.	No.
P.										
△ = ± 25 g. r.t.	1.292s	1.276s	1.152s	1.113s	1.189s	1.262s	1.285s	1.276s	1.228s	1067
△ = ± 0 g. r.t.	1.280s	1.223s	1.249	1.201	1.211	1.225	1.312	1.293	1.245	977
G.										2044
△ = ± 25 g. r.t.	1.007	1.004	.958	.942	.964	.980	1.013	.996	.983	812
△ = 1 0 g. r.t.	1.049	1.050	1.042	1.017	1.025	1.043	1.056	1.083	1.043	901
W.										1713
△ = ± 25 g. r.t.	.887	.803	.746	.780	.809	.819	.769	.839	.831	401
△ = 0 g.	.945	.762	.915	.797	.884	.853	.966	.938	.894	465
S.										866
△ = ± 25 g. r.t.	1.077	.983	.992	.935	.993	1.036	1.059	1.143	1.027	210
△ = 0 g. r.t.	1.098	1.083	1.158	.976	1.032	1.254	1.072	1.082	1.190	246
F.										456
△ = ± 25 g. r.t.	.702	.848	.850	.881	.908	.926	.683	.818	.838	141
△ = 0 g. r.t.	.781	.959	.818	.770	.895	.740	.826	.839	.829	157
										298

gm., that in the case of P., the reaction times decrease gradually from the 1st interval (1.292 s) on to the fourth (1.113 s) and then rise again more or less gradually during the remaining four intervals; in the case of G., essentially the same course is shown. The decline is from 1.007 s in the first to .942 s in the 4th, and the rise during the remaining four; in case of W., there is decline from .887 s in the first to .746 s in the third, with a steady rise to the end, with the exception of a drop to .769 s in the 7th; in case of S., a course somewhat irregular, but with the values higher for the latter intervals than for the earlier and with the minimum of .935 s in the 4th interval; in case of F. a still more irregular course, with a maximum of .926 s in the 6th interval and a minimum of .683 s in the 7th.

For △ = 0 gm., the general results are much the same. The reaction-time declines for P. from 1.280 s in the first to 1.201 s in the fourth, rising in a fairly gradual way during the last four intervals. G. shows an irregular decline from 1.049 s in the first to 1.017 s in the 4th., with a gradual rise during the remaining. In case of W., there is less regularity in the course

of the reaction time for this weight interval than for the other: The minimum of .762 s is reached in the 2nd interval, and the maximum of .915 s in the 4th, and then an irregular rise during the latter intervals. S. shows a gradual decline from 1.098 s in the first to .976 s in the 4th, and then an irregular rise during the latter intervals. F.'s course is irregular, the minimum of .770 s occurring in the 4th interval and the maximum of .959 s in the 2nd. The reaction times are in general higher for the difference $\Delta = 25 \pm$ gm., than for no difference. Taking the average of all the intervals, we have the following: P. 1.228 s for $\Delta = \pm 25$ gm., and 1.245 s for $\Delta = 0$ gm.; G., .983 s and 1.043 s resp.; W., .831 s and .894 s resp.; S., 1.027 s and 1.190 s resp.; F., .838 s and .829 s resp., the single exception to the statement.

The most, therefore, that we are entitled to say is, that there is gradual decline in the reaction time during the first 50 or 60 seconds, and then some increase for longer intervals of time. Fifty to sixty seconds seems to be the most favorable interval for judging the weights so far as the shortness of reaction can be taken to indicate this. This accords with what Prof. Angell found in his experiments on the discrimination of shades of gray for different intervals of time, though he did not extend them beyond 60 secs.[1]

The general statements just made are still further confirmed, on examining the values of the reaction time for right and wrong judgments treated separately, as will be seen by inspecting the following table:

Confining our attention at first to right judgments for $\Delta = \pm 25$ gm., we find that in case of P. the reaction time drops from 1.154 s in the first interval to 1.039 s in the third and rises in a fairly regular way to 1.189 s in the 8th; in case of G., a slightly irregular fall from .955 s in the 1st to .892 s in the 5th; with a somewhat higher level of values in the last three; in case of W., a decline, fairly regular, from .927 s in the 1st to .670 s in the 5th, and gradual rise during the last three to .729 s in the 8th; for S., an irregular fall from 1.010 s in the 1st to .803 s in the 4th, with higher values in the latter places; for F., an irregular course, with minima of .682 s in the 1st and .644 s in the 7th, and a maximum of .997 s in the 5th.

The average for wrong judgments for this weight difference shows a rough tendency to follow the same general course as do the right judgments. P's figures rise and fall till the 4th interval when a minimum of 1.177 s is reached, after which there is a fairly regular rise to 1.376 s in the 8th interval. About the same is true of G., who has a minimum of 1.046 s

[1] Phil. Studien, Vol. XIX, p. 19.

TABLE II.

Reaction Time in seconds for Right and Wrong Judgments. N. standard stimulus; V. stimulus of comparison; r. right and w. wrong judgments.

t. i.	20s.	30s.	40s.	50s.	60s.	80s.	100s.	120s.	Av.	No.
Dr. Pills.										
$\Delta = \pm 25$.										
r: V ≷ N	1.154s	1.123s	1.039s	1.072s	1.131s	1.150s	1.200s	1.189s	1.135s	545
w: V ≷ N; r.t.	1.286	1.342	1.240	1.140	1.270	1.366	1.368	1.351	1.298	293
w: VIII N; r.t.	1.338	1.370	1.295	1.246	1.237	1.350	1.384	1.396	1.311	229
w: Av.; r.t.	1.313	1.354	1.364	1.177	1.260	1.358	1.376	1.376	1.304	522
										1067
$\Delta = 0$										
r: VIII N; r.t.	1.271	1.182	1.236	1.158	1.247	1.259	1.276	1.293	1.231	311
w: V < N; r.t.	1.293	1.275	1.250	1.207	1.128	1.291	1.327	1.303	1.252	302
w: V > N; r.t.	1.283	1.266	1.269	1.250	1.226	1.134	1.313	1.287	1.249	364
w: Av.; r.t.	1.287	1.252	1.262	1.260	1.168	1.211	1.319	1.293	1.250	666–977
Mr. G.									grand	tot'l 2044
$\Delta = \pm 25$										
r: V ≷ N; r.t.	.955	.874	.909	.896	.892	.928	.934	.903	.916	481
w: V ≷ N; r.t.	1.069	1.085	1.046	1.040	1.054	1.070	1.137	1.067	1.074	145
w: VIII N; r.t.	1.082	1.098	1.063	1.051	1.045	1.077	1.123	1.112	1.083	186
w: Av.; r.t.	1.075	1.092	1.057	1.046	1.047	1.074	1.127	1.089	1.079	331
										812
$\Delta = 0$										
r: VIII N; r.t.	1.041	1.048	1.037	.991	.983	1.030	1.047	1.057	1.029	309
w: V < N; r.t.	1.070	1.053	1.042	1.029	1.047	1.044	1.057	1.062	1.052	294
w: V > N; r.t.	1.044	1.048	1.054	1.041	1.056	1.052	1.060	1.058	1.051	298
w: Av.; r.t.	1.057	1.050	1.048	1.036	1.052	1.048	1.058	1.068	1.052	592–901
Mr. W.									grand	tot'l 1713
$\Delta = \pm 25$.										
r: V ≷ N; rt.	.927	.803	.677	.670	.703	.652	.694	.729	.709	230
w: V ≷ N; rt.	.736	.921		1.307	.877	1.031	.818	1.133	.868	122
w: VIII N; rt.	.949	.709	.832	.821	.968	1.174	.894	.937	.917	49
w: Av.; rt.	.863	.803	.832	.967	.944	1.042	.819	1.014	.901	171
										401
$\Delta = 0$										
r: r.t.	.892	.648	.763	.578	.741	.698	1.030	.964	.827	212
w: V < N; r.t.	.832	.901	1.183	.944	.988	.847	.994	.898	1.011	174
w: V > N; r.t.	1.970	.696	.539	1.013	.889	.972	.728	.957	.812	79
w: Av.; r.t.	1.060	.815	1.041	.965	.950	1.007	.892	.915	.967	253–465
Mr. S.									grand	total 866
$\Delta = \pm 25$.										
r: V ≷ N; r.t.	1.010	.933	.969	.803	.660	1.070	1.039	1.016	.956	131
w: Av.; r.t.	1.157	1.126	1.038	1.140	1.085	.992	1.078	1.148	1.118	79
										210
$\Delta = 0$										
r: VIII N; r.t.	1.165	.688	1.214	1.161	1.154	1.167	1.207	1.118	1.027	97
w: Av.; r.t.	1.015	1.165	1.108	.976	1.314	1.105	1.016	1.221	1.113	149–149
									grand	total 456

TABLE II.—*Continued.*

t. i.	20s.	30s.	40s.	50s.	60s.	80s.	100s.	120s.	Av.	No.
Mr. F.										
$\Delta = \pm 25$.	.682	.890	.819	.770	.997	.916	.644	.755	.817	72
r: V ≷ N;	.738	.838	.866	1.008	.785	.939	.721	.888	.845	69
w: } Av.; r.t.										141
$\Delta = 0$	.835	.938	.830	.716	.907	.782	.656	.887	.811	62
r: VIIIN;	.727	.977	.874	.809	.886	.717	.904	.807	.843	95–157
w: } Av.; r.t.									grand	total 298

in 4th, with a fairly regular ascent to 1.089 in the 8th; W. is irregular, with a minimum of .803 s in the 2nd, and a maximum 1.042 s in the 6th; S. shows a fall from 1.157 s in the 1st to 1.038 s in the 3rd, with an irregular course for the remaining intervals. For F, the course of values is irregular, varying from minima of .738 s and .785 s in the 1st and 5th to a maximum of 1.008 s in the 4th.

Of the wrong judgments, the class "V ≷ N" or "unlike" shows the following: P., a fairly regular descent from 1.286 s in the first to 1.140 in the 3rd, with an irregular ascent to 1.351 s in the 8th; G., a slight drop from 1.069 s in the first to 1.040 s in the 4th, with a slightly irregular course of higher values for the remaining intervals; W., an irregular course of values ranging from minima of .736 s and .818 s in the 1st and 7th, to a maximum of 1.307 s in the 4th.

The other class of wrong judgments, "VIIIN" or "like," yield similar results. We have in case of P., a fall from 1.338 s in the 1st to 1.237 in 5th, with a rise from 1.350 s in the 6th to 1.396 in the 8th; in case of G., a fall, a little irregular, from 1.082 s in the 1st to 1.045 s in 5th, with irregular higher values for the remaining three; in case of W., an irregular ascent from .803 s in the 2nd to 1.042 s in the 6th, with an irregular drop to 1.014 in 8th.

Taking the average for all the intervals, we see that right judgments are shorter on the whole than wrong judgments, being for the different reagents as follows: P., 1.135 s for right and 1.304 s for wrong; G., 1.231 s and 1.250 s, respectively; W., 709 s and 901 s, respectively; S., 956 s and 1.118 s, respectively; F., .817 s and 845 s, respectively; "VIIIN" or "like" judgments are longer than "unlike," "V ≷ N" judgments (P., 1.311 s and 1.298 s; G., 1.083 s and 1.074 s; W., .917 s and .868 s.)

Passing to the results tabulated for $\Delta = 0$ gm., in which norm and comparison stimuli are the same, we find about the same

things as we did for $\Delta = \pm 25$ gm., though the tendencies there noted are not so pronounced in the present instance. P.'s figures for right judgments fall irregularly from 1.271 s in the first to 1.158 s in the fourth, and then rise quite regularly during the rest of the intervals to a final of 1.293 s; G.'s results are similar to these, decline a little irregularly from 1.041 s in the first to .983 s in the 5th, with a small regular ascent to 1.057 in the 8th; W's course is irregular, with minima of .648 s in the 2nd, and .578 s in the 4th and a maximum of 1.030 s in the 7th. S.'s course is likewise irregular with a minimum of .988 s in the 2nd and a maximum of 1.207 s in the 8th. F. has a minima of .716 s in the 4th, after an irregular decline from .835 s in the 1st, with another minimum of .656 s in the 7th interval.

For the average of both classes of wrong judgments, we find for P., an irregular fall from 1.287 s in the 1st to 1.168 s, in the 5th, with an irregular rise to 1.293 s in the 8th; for G., a quite regular decline from 1.057 s in the 1st to 1.036 s in the 4th, with an irregular ascent to 1.068 s in the 8th; for W., an irregular course with a minimum of 815 s in the 2nd, and another of .892 s in the 7th and a maximum 1.007 s in the 6th; for S., an irregular fall to .976 s in the 4th, with irregular higher values in the latter intervals. For F., an irregular course with a minimum of .727 s in the 1st and another of .717 s in the 6th, and a maximum of .977 s in the 2nd and one of .907 in the 7th.

Of the two classes of wrong judgments, "V⟨N" give us for P. a fall, quite regular from 1.293 s in the 1st interval to 1.128 s 5th, with an abrupt, irregular ascent to 1.303 s in the 8th; for G, a fairly regular fall from 1.070 s in the 1st to 1.029 in the 4th, with a fairly regular rise to 1.062 in the 8th; for W., an irregular course of .832 s in the 1st and 847 s in the 6th as minima with a maximum of 1.183 s in the 3rd. "V⟩N" judgments give in case of P. a fall, regular, from 1.283 s in the 1st to 1.134 s in the 6th, with somewhat higher values in the remaining two intervals; for G., a rise and fall to a minimum of 1.041 in the 4th, and irregular higher values in the remaining four; for W., an irregular course with a minimum of .539 s in the 4th.

Comparing the averages for all eight intervals of time taken together we find again right judgments shorter than wrong: (P. 1.231 s and 1.250 resp.; G. .916 and 1.079 resp.; W. .827 s and .967 s resp.; S., 1.027 s and 1.113 s, resp.; F., .811 s. and .843 s resp.)

Of the two classes of wrong judgments, "V ⟨ N" are longer than "V ⟩ N" in case of P (1.25 s and 1.249 s resp.) about the same in case of G (1.052 s and 1.051 s resp.), longer for W (1.011 s and .812 s resp.)

Now for $\Delta = O$, "VIIIN" judgments are right judgments; and while as noted above these are shorter than wrong judgments, yet the peculiar nature of "like" judgments again is seen in the fact that relative to the wrong judgments the right for $\Delta = O$ are higher than for $\Delta = \pm$ 25 gm., the ratios being respectively as follows: P 1.01 and 1.15; G. 1.02 and 1.17; W, 1.17 and 1.27; S, 1.08 and 1.17.

The reaction times have also been calculated for the totals of the three classes of judgments which the introspective records developed, viz.: "absolute," "mixed" and "direct;" and the same are presented in the following table:

TABLE III.

Reaction Time in Relation to Nature of Judgment.

$\Delta = \pm$ 25 gm.

	Nature of Judgm't.		Right (V ≷ N)	Wrong. V ≶ N	Wrong. VIIIN	Wrong. Av.	Av. for all.
Dr. P.	Absolute;	rt.	1.098s	1.219s	1.262s	1.237s	1.153s
	Mixed;	"	1.187	1.356	1.340	1.351	1.279
	Direct;	"	1.119	1.300	1.364	1.320	1.256
Mr. G.	do	"	.864	.955	.937	.945	.940
	do	"	1.001	1.238	1.227	1.236	1.121
	do	"	.896	.983	1.086	1.048	1.024
Mr. W.	do	"	.668	.886	.789	.881	.755
	do	"	.725	1.017	1.122	1.055	.870
	do	"	.863	1.217	.918	1.045	.919
Mr. S.	do	"	.945			1.068	.974
	do	"	1.065			1.200	1.124
	do	"	.907			1.045	1.000

$\Delta = 0$ gm.

	Nature of Judgm't.		Right (VIIIN)	Wrong. V < N	Wrong. V > N	Wrong. Av.	Av. for all.
Dr. P.	Absolute;	rt.	1.212s	1.238s	1.242s	1.240s	1.229s
	Mixed;	"	1.258	1.268	1.250	1.259	1.261
	Direct;	"	1.225	1.228	1.259	1.248	1.241
Mr. G.	do	"	1.006	1.039	1.048	1.043	1.031
	do	"	1.050	1.067	1.056	1.062	1.058
	do	"	1.024	1.054	1.055	1.054	1.045
Mr. W.	do	"	.820	1.021	.920	.994	.928
	do	"	.726	1.103	.659	.912	.798
	do	"	.997	1.244	1.360	1.272	1.140
	Immediate	"	1.098			1.121	1.102
Mr. S.	do	"	1.110			1.165	1.142
	do	"	1.265			.951	1.048
	do	"	1.100			1.001	1.045

For $\triangle = \pm 25$ gm. we note that, both right and wrong judgments taken together, the reaction time of "the absolute" is the least, the distribution for the "absolute" "mixed" and "direct" is: P., 1.153 s, 1.279 s, and 1.256 s; G., .940 s, 1.121 s, 1.024 s; W, .755 s, .870 s, and .919 s; S, .974 s, 1.124 s, 1.000 s.

Right ("V ≶ N") absolute judgments are also less than right judgments of either "the mixed" or "direct" class, with one exception, S. with whom "direct" are shortest. Right judgments are also shorter than the average of both classes of wrong judgments. Thus in case of P., the reaction times in "absolute," "mixed" and "direct" respectively are for right judgments, 1.098 s, 1.187 s, and 1.119 s, and for wrong, 1.237 s, 1.351 s, 1.320 s; in case of G., .864 s, 1.001 s, and .896 s for right, and for wrong, .945 s, 1.236 s, 1.046 s; W., .668 s, .725 s and .863 s, for right, and .881 s, 1.055 s and 1.045 s for wrong; S, .945 s, 1.065 s and .907 s for right and 1.068 s, 1.200 s, 1.045 s. The "mixed" right and wrong judgments are the longest with one exception, W., for whom "direct" right judgments are the longest. This seems to indicate that a complication of memorial images with verbal supplementation interferes in a measure with the comparison of the normal stimulus, so far as reaction time can be taken to indicate anything in the matter.

Taking the average for both kinds of wrong judgments, we find in all cases the "mixed" to be the longest and with one exception (S.), the "absolute" to be the shortest, the results being as follows: P., 1.237 s, 1.351 s, and 1.320 s for "absolute," "mixed" and "direct" respectively; G., resp. .945 s, 1.236 s, 1.048 s; W., resp., .881 s, 1.055 s, 1.045 s; S., resp., 1.068 s, 1.200 s, 1.045 s.

For "V ≶ N" wrong judgments (unlike), we have in case of P., the absolute shortest (1.219 s) and the mixed longest (1.356 s); in case of G., the same ("absolute," .955 s and "mixed" 1.238 s); in case of W, the "absolute" shortest (.886 s) and "direct" longest (1.217 s).

The results show that for "VIIIN" wrong judgments (unlike) the absolute are in all cases the shortest, being for P., 1.262 s; for G., .937 s and for W., .789 s; and that in case of P., "direct" are longest (1.364 s), in case of G., "mixed" are longest (1.227 s), and in case of W., mixed are also longest (1.122 s).

The results tabulated for $\triangle = 0$ g. are on the whole like those for $\triangle = \pm 25$ gm., though less pronounced. Referring to the averages for all judgments (both right and wrong), we find the "absolute" to be the shortest with one exception W., and the "mixed" the longest with one exception W., the several values being these: P., "absolute," 1.229 s; "mixed,"

1.261 s; "direct," 1.241 s; G., resp. 1.031 s, 1.058 s, 1.045 s; W, .928 s, 798 s, 1.140 s resp.; S., 1.142 s, 1.048 s, 1.045 s, resp. And the values of the "absolute" judgments are on the whole higher for $\Delta = 0$ gm. than for $\Delta = \pm 25$ gm., though this relation does not hold true in case of "mixed" and "direct."

Of the right judgments ("VIIIN"), "the absolute" are with one exception (W.), the shortest, and with one exception (W.), the "mixed" are the longest. And the values of the right judgments are on the whole considerably higher there than they are for $\Delta = \pm 25$ gm.

Passing to the average of wrong judgments, we note that the "absolute" are shortest for P. and G., and the "direct" for W., and the absolute for S.

The "V⟨N" wrong judgments are shortest in case of the direct for P.; in case of the "absolute," for both G. and W. The longest of these judgments appears among the "mixed" for P. and G., and among the "direct" for W.

Of the "V⟩N" wrong judgments, the "absolute" are shortest for P. and G., and the "mixed" for W.; the direct are the longest for P. and W., and the "mixed" and "direct" about the same for G.

B. *Effect of Length of Memory Interval on Mean Variation.* The mean variations have been calculated for the various intervals and for total values, not only to obtain some idea of the trustworthiness of the data presented, but also to see if any additional light was thrown on the nature of the judgment-process itself. For these purposes the following table is annexed:

TABLE IV.

Relative Mean Variation $\left(\frac{m\,v}{v}\right)$ *in relation to the Time Interval.*

t. i.	20	30	40	50	60	80	100	120	Av.
$\Delta = \pm 25$ gm.									
Dr. P.									
r: V⋛N	20+%	19+%	16+%	16—%	14+%	15+%	14+%	16+%	16+%
w: V⋛N	22+	23+	18+	18—	17+	17—	15+	21—	19+
w: VIIIN	23—	24+	21—	23+	19+	17+	16+	17+	24—
w: Av.	23—	23+	19+	19—	17+	17—	16—	15+	19—
Av. for r.+w.	19+	21+	17—	16+	15+	16+	16+	17—	15+
Mr. G.									
r: V⋛N	20—	17+	15+	16—	14+	13+	16+	14+	15+
w: V⋛N	21+	22+	20—	18+	17—	14+	16—	16—	18—
w: VIIIN	23+	18+	20—	21—	17+	16+	14+	12+	19+
w: Av.	22+	20—	20+	19+	18—	15+	15—	16+	20+
Av. for r.+w.	21+	18+	17+	19—	15—	13—	16+	14—	16+

TABLE IV.—*Continued.*

t. i.	20	30	40	50	60	80	100	120	Av.
Mr. S.									
r: V≷N	17+	14—	13—	15+	18—	18+	21+	19+	16—
w: V≶N									
w: VIIIN									
w: Av.	21+	22—	17—	15—	23—	20+	22—	20+	18+
Av. for r.+w.	18—	15—	14—	17+	20+	21—	11+	19+	17+
Mr. W.									
r: V≷N	17+	12—	20+	13+	13—	18+	13+	14+	14+
w: V≶N	13+	14—	12+	13+	9+	12+	10+	9+	13+
w: VIIIN	16—	12—	16+	18+	12—	14+	9+	13—	17+
w: Av.	9+	10+	12+	14+	10+	12+	10+	16+	14—
Av. for r.+w.	20+	11+	16+	15+	11+	18+	14—	15—	14—
Mr. F.									
r:	23—	16—	20+	23+	18+	15—	17—	19+	18+
w: V≶N									
w: VIIIN									
w: Av.	18—	19—	17+	16+	21—	19—	22+	20+	17—
Av. for r.+w.	22+	17+	19—	19+	20+	17—	21—	16+	19+
△ = 0 gm.									
Dr. P.									
r: VIIIN	23—	21+	20	17+	15+	17—	16+	15+	18+
w: V<N	21+	24—	20—	19+	17—	18—	19+	20—	19+
w: V>N	23+	21—	22—	18+	17+	19—	17+	16—	17+
w: Av.	23—	19+	21+	22—	18—	17+	19—	19+	20—
Av. for r.+w.	20—	22—	20+	20—	17—	18—	16+	18+	19+
Mr. G.									
r: VIIIN	20—	22+	21—	18+	16+	17+	15+	18—	19—
w: V<N	22+	21+	24—	20—	19—	21—	23+	22—	21+
w: V>N	19+	20—	23+	23—	10+	17+	20—	19—	19+
w: Av.	21—	20+	24—	21+	19+	19—	21—	20+	20—
Av. for r.+w.	20+	22—	20+	18+	16+	20—	21+	20—	18+
Mr. W.									
r: VIIIN	11—	25—	16+	12+	12+	16—	24+	10+	18—
w: V<N	10+	15+	14+	14+	16—	11—	12—	15+	13+
w: V>N	6—	11—	20—	10+	20—	—	15—	12+	18+
w: Av.	15+	14+	17+	13+	15+	15+	15+	12+	16—
Av. for r.+w.	13+	16+	18—	18+	16+	18+	18+	13+	17—
Mr. S.									
r: VIIIN	19+	22—	17—	15—	18—	16—	20+	19+	18—
w: V<N									
w: V>N									
w: Av.	18—	16+	20+	21+	19—	18+	17+	22—	20—
Av. for r.+w.	17+	18+	19+	21+	17—	21—	18+	18+	18+
Mr. F.									
r: VIIIN	16+	20+	22—	16+	15—	14—	19+	20+	18—
w: V<N									
w: V>N									
w: Av.	22—	17+	15+	20+	18+	21+	17—	16+	20—
Av. for r.+w.	18—	16+	18+	21—	17—	16+	21+	18—	17—

$\Delta = \pm 25$ gm: For the two most important subjects, P. and G., there is, taking the average for all the intervals, less variation for right than for wrong judgments, and for S. the same is true; for W., the variation is equal in the two instance; for F. it is less in wrong judgments. Between the two classes of wrong judgments, "V $\gtrless$ N," and "V III N," the variation is less in the former than in the latter for the three reagents, P., G., and W. This result is taken to confirm the conclusion previously drawn from the reaction time of the two classes of wrong judgments. As noted before, "like" judgments have an element of uncertainty in them depending upon the absence of the criteria available in the other classes of judgments, with the consequence that they are not only longer, but also more variable.

As regards the relation between the different time intervals and their respective mean variations, no evidence is forthcoming of the influence of a factor having the definite relation to the time that the memorial image has been assumed to possess. For right judgments, we have in case of P. a fairly uniform drop from 20+% to 14+% during the first five intervals, with an average above 14+% for the remaining three. This follows closely the relation between reaction time and the time brought out in table I, the minimum being 1.113s for the 4th interval (50 sec.). For G., we have a more or less constant decline from 20—% to 13+%, during the first six intervals, and a higher average for the remaining two. We have here again a close parallel to the course of the reaction time, though it should be noted that the minimum reaction time is reached two intervals earlier (in the 4th). For W., no definite tendency is apparent, the minimum of 12—% occurs in the 2nd interval and the maximum of 20+% in the third. For S., there is a decline from 17+% to 13—%, during the first three intervals, with an irregular higher level maintained during the remaining five. In case of F., the course is irregular throughout, with a minimum of 15—% in the 5th interval and a maximum of 23+% in the 4th.

Taking both classes of wrong judgments together, we find there is a fairly regular decline in case of P. from 23—% in the 1st to 15+% in the last; in case of G., a fall from 22+% to 18—% during the first five, and a somewhat lower level for the remaining three; for W. a gradual increase from 9+% to 14—% in the first four, and an irregular course for the last four; for S, an irregular decline from 21+% in the 1st to 15—% in the 4th, with a considerably higher level for the remainder; for F., the course is irregular throughout.

Of the two classes of wrong judgments, "V $\lesseqgtr$ N" judgments ("unlike" judgments) yields the following results: For

P. there is a more or less graded decline from 22+% to 15+% during the first seven intervals, with a sudden jump to 21—% in the 8th; for G. there is a level of about 20% for the first three, a decline from 18+% to 14+% in the next three, and a level of about 16% for the last two; for W., the course is irregular, values ranging from a minimum of 9+% in the 5th, to a maximum of 14—% in the 2nd; for S. and F., wrong judgments have not been separated into the two classes, because the number of cases was thought too small. The other class of wrong judgments, "VIIIN" or "like" judgments, furnishes the following: for P., the course maintains a level of about 23% during the first four intervals, with a gradual drop from 19+% to 16+% during the next three, and a jump to 19+ in the 8th; for G., there is during the first four a fairly constant level of about 20% with a fairly regular decline from 17+% to 12+% during the last four; for W., the course is irregular as in the case of the other class of wrong judgments, though the average is somewhat higher (17+% as against 13+%). The net result of the foregoing, so far as wrong judgments are concerned, is that no influence capable of a precise mathematical formulation is observable, though for the two most important reagents, P. and G., we are entitled to say that the mean variation is higher for the earlier intervals, though in the 8th interval high values again appear in P.'s case.

Taking the averages for both right and wrong judgments, we have in case of P., a level of about 20% during the first two intervals, and slight variation around 16% during the other six; in case of G., an irregular decline from 21% in the first to 13—% in the 6th, with a drop from 16+% to 14—% in the last two; in case of W., an irregular course, with values ranging from a maximum of 20+% in the first to a minimum of 11+% in both the 2nd and the 4th; for S., an irregular course with a maximum of 20+% in the 5th interval and a minimum of 11+ in the 7th; for F., an irregular course with values higher in the latter intervals.

$\Delta = 0$ gm. In the case of right judgments, which for this increment are "VIIIN" judgments, we note the following: P.'s results follow the same general law as in the interval of $\Delta = \pm 25$, viz., a fairly uniform decline from 23—% in the first interval to 15+ in the 5th, and G., the same, the values for both reagents being higher than the corresponding values for $\Delta = \pm 25$; W.'s results are again irregular throughout, ranging from minimum of 11—% in the first and 10+% in the 8th, to a maximum of 25—% in the 2nd and 24+% in the 7th, with an average variation for the eight intervals of 18—%; S. shows an irregular decline from 19+% in the first to 15—% in the 4th, and an irregular course of higher values beyond this; F. has irregular

maximum values in the first three and last two intervals, and considerably smaller minimum values for the middle intervals. On the whole the peculiar nature of "VIIIN" judgments is again manifest in the higher relative mean variations.

Taking both classes of wrong judgments (V⟨N and V⟩N) together, we find that the average mean variation for the eight intervals is higher than the corresponding mean variations for right judgments in the case of P. (20—% and 18+%), higher in case of G. (20—% 19—%), less in case of W. (16--% and 18—%), higher in case of S. (20—% and 18—%), higher in case of F. (20—% and 18—%). Comparing these results with the corresponding ones for $\Delta = \pm$ 25 gm., we get the following: P.'s results are about the same (20—% and 19—); so likewise G.'s (20—% and 19—%); W. higher for $\Delta = O$ (16% and —14%); S. higher for $\Delta = O$ (20—% and 18+); F. higher for $\Delta = O$ (20—% and 17—%). By comparing the two weights intervals in respect to the average variation for all judgments taken together, the following results appear: P. is more accurate for $\Delta = \pm$ 25 gm. (15+% and 19+%); G. the same as P. (16+% and 18+%); W. is equally accurate in both intervals (14—%). S. is more accurate for $\Delta = \pm$ 25 gm. (17+% 18+%); F., about the same for both (19+ and 19—). On the whole, therefore, the reagents show greater constancy for the larger weight intervals.

Of the two classes of wrong judgments, "V⟨N" and "V⟩IV," neither show very decided tendencies. With P. there is for "V⟨IV" judgments a drop from 21+% and 24%— respectively in the first two, to 17— in the 5th and then a gradual rise to 20—% in the 8th, and for "V⟩IV" judgments an irregular fall from 23+% in the 1st to 17+ in the 5th, and a drop from 19—% in the 6th to 16— in the 8th; in case of G., "V⟨N" judgments have an irregular course, giving values ranging from 19—% in the 5th to 24—% in the 3d, "V⟩N" judgments likewise irregular with a minimum of 17+% in the 6th and a maximum of 23+ in the 3d; for W., "V⟨N" judgments are irregular, with values ranging from 10+% in the 1st, to 16—% in the 6th, while "V⟩N" have a lower minimum of 6—% in the 1st and a higher maximum of 20—% in the 3rd and 5th. Taking the mean variation for the full eight intervals we find the mean variation of "V⟨N" judgments higher than the mean variation of "V⟩N" judgments in case of P. (19+% and 17+%), higher in case of G. (21+% and 19+%), less in case of W. (13+% and 18+%).

The results for the mean variations of both right and wrong judgments taken together are these: P.'s figures follow the tendency noted for $\Delta = \pm 25$ gm, of declining to a minimum in the fifth interval with a slight rise for the remaining three intervals; though the tendency is less obvious, we have the

same general features in the course G.'s figures; while with the remaining three reagents the course is irregular throughout. The mean variation for the 8 intervals considered as a whole is higher for $\Delta = 0$ gm. than for $\Delta = \pm 25$ gm, in case of P. (19+% and 15+%), G. (18+% and 16+%), W., (17—% and 14—%), and S. (18+% and 17+%), but the opposite for F. (19+% and 17%).

The mean variations have also been calculated for the totals of the three different classes of judgments, "absolute," "mixed," and "direct," and are embodied in the following table.

TABLE V.

Relative Mean Variation $\left(\frac{m\,v}{v}\right)$ *for the different kinds of Judgments.*

$\Delta = \pm 25$ gm.

Nature of Judgment.	Re-agents.	Right V ≷ N	Wrong. V ≷ N	Wrong. V ⋛ N	Wrong. Av.	Av. for all.
Absolute,	Dr. P.	15+%	19—%	20—%	18+%	17+%
Mixed,		17—	21+	24—	22+	21—
Direct,		18—	22+	18+	21+	20+
do	Mr. G.	16—	17+	19+	18—	17—
do		17+	18+	21+	20—	18+
do		15+	20—	18+	19+	17+
do	Mr. W.	15—	12+	15—	12+	12+
do		16—	12+	—	11—	16+
do		18+	—	—	20+	19+
do	Mr. S.	15+			17—	18—
do		18+			24—	20+
do		16+			18—	17+

$\Delta = 0$ gm.

	Reag'ts	Right V ⋛ N	Wrong. V < N	Wrong. V > N	Wrong. Av.	Av. for all.
Absolute,	Dr. P.	17—	19—	20+	21—	18+
Mixed,		19+	21+	22—	18+	20+
Direct,		24+	15+	18—	16+	17—
do	Mr. G.	18+	18+	21—	20—	20+
do		19+	20—	21—	18+	19+
do		21+	24—	20+	22—	22+
do	Mr. W.	15+	14—	16+	15—	16+
do		18+	12+	8+	18+	19+
do		18+	—	—	11+	15+
do	Mr. S.	17—			18+	16—
do		19+			23+	21—
do		18+			13—	16—

The figures recorded above agree quite closely in their import with those given in the preceding table. For $\Delta = \pm 25$ we find that right judgments are on the whole less variable

than wrong judgments. Thus in P.'s case the variation is 15+, 17—%, 18—% for right judgments, against 18+%, 22 +%, 21+% respectively for wrong judgments; G., 16—%, 17+%, 15+%, against 18—%, 20—%, 19+%, respectively; S., 15+, 18+, 16+, against 17—%, 24—%, 18—%; but in case of W. the values are anomalous, being 15—%, 16 —%, 18%, against respectively, 12+%, 11—%, 20+%. Between the two classes of wrong judgments, "VIIIN" (like) judgments show higher values as a rule than "V ≶ N" (unlike) judgments, being for P., 20—% to 19—%, 24—% to 21+ %, 18+% to 22+%; for G. 19+% to 17+%, 21+% to 18+%, 18 +% to 20—%; for W., 15—% to 12+%. Right "absolute" judgments show as a rule least variation as compared with other right judgments: thus for "absolute" right judgments the mean variation is 15%+; for mixed, 17—%; for direct, 18—% in case of P.; 16—%, 17+%, and 15+ respectively in case of G.; 15—%, 16—%, 18+% in case of W.; 15+%, 18+%, 16+% in case of S. The exception here of 15+ % for "direct" judgments in case of G., does not invalidate the general statement, for the number of direct judgments is comparatively small.

Of wrong judgments, the "unlike," "V ≷ N," follow the same general rule; for P., "absolute" have a mean variation of 19—%; "mixed," 21+%; "direct," 22+%; for G., 17+%, 18+%, 20—% respectively; but the other class of wrong judgments, "VIIIN" (like) is anomalous, the results being: P., "absolute" 20—%; "mixed," 24—%; "direct," 18%; G., "absolute," 19+%; "mixed," 21+%; "direct," 18+%, though it should be noted that in both instances, the mixed judgments have a higher mean variation than the absolute.

The interval $\Delta = 0$ gm. shows less decided tendencies than the interval $\Delta = \pm 25$, just discussed. Right judgments are not on the whole less variable than wrong: thus for P., we have for right judgments, 17—%, 19+%, 24+%, against 21—% 18+%, +16% for wrong; in case of G., 18+%, 19+%, 21+%, for right against 20—%, 18+%, 22—% resp., for wrong; in case of W., 15+%, 18+%, 18+% for right against 20—%, 18+%, 22—% resp., for wrong; in case of S., 17% 19+%, 18+%, for right judgments against 15—%, 18+%, 11+%, resp., for wrong judgments. Comparing the different kinds of judgments, we find consistent results among the right judgments. The mean variations are respectively 17—%, 19+%, 24+%, for the "absolute," "mixed," and "direct" in case of P.; 18+%, 19+%, 21+% resp., in case of G.; 15+%, 18+%, 18+% resp., in case of W.; and 17—%, 19+%, 18+% in case of S. As compared with the corresponding values for the difference of $\Delta = \pm 25$ gm., the results are somewhat higher, bringing to light again the peculiar nature of "like" judgments ("VIIIN").

Taking the totals for the different classes of judgments, we find the mean variation to be less for "absolute" judgments than it is for "mixed" with one exception, G.; the value being P. 18+% and 20+% resp.; for G., 20+% and 19+resp.; for W., 16+%, and 19+%, resp.; for S., 16—%, and 21 —% resp.

C. *Effect of Memory Interval upon the Percentage of Right and Wrong Judgment.* Herewith are appended the results obtained under the above head.

TABLE VI.

Percentage of Right and Wrong Judgments for the different intervals of time.

t. i.	20	30	40	50	60	80	100	120	Percentage of all judgments.
△ ± 25 gm.									
Dr. P.									
r. V≷N	42	34—	63—	61+	52—	46+	52—	53+	51+
w. V≤N	30	38—	19—	26—	34+	33—	22+	19—	27—
w. VIIIN	28	28+	18+	13+	14+	21—	26—	26—	22—
Mr. G.									
do	57—	53—	67—	69+	53+	64+	58+	49+	59+
w, do	20+	21—	12+	15+	15—	16+	17+	26+	18—
w, do	23—	26+	21+	16—	32—	19—	24+	24+	23—
Mr. W.									
do	37+	60—	56—	63—	56—	57+	56—	61—	58—
do do	37+	22+	44+	26—	32+	32+	26—	25—	30+
do	25—	18+		11+	12—	11—	18+	14+	12+
Mr. S.									
do	73+	74+	70+	61+	62+	57—	50	45+	63+
do do	27—	26—	9—	39—	38—	43+	50	55—	37—
△ = 0 gm.									
Mr. G.									
r. VIIIN	49+	38+	53—	41+	39—	27—	23+	15—	34+
w. V<N	27+	35+	21+	26—	30+	32—	36—	48+	33—
w. V>N	24—	27—	26+	33+	31+	41+	41—	37+	33+
Dr. P.									
do	45	41	50	37+	32+	29+	18—	9+	32—
do do	21	21—	24+	29—	34—	35—	41—	36+	11—
do	30	38+	25+	34+	34+	36+	41+	55+	37+
Mr. W.									
do	69	31+	49—	33+	31+	50	53+	46+	46—
do do	25	39—	40+	40—	41—	40	28+	38+	37+
do	6	30+	11+	17—	28—	10	18+	15+	17+
Mr. S.									
do	52—	45—	48+	33+	37+	36+	35	35+	39+
do do	48+	55+	42—	67—	62+	64—	65	65—	61—

The percentage of right cases does not seem to follow any very definite tendency in relation to the time interval. P.'s result shows an irregular rise from 42% in the first interval to 63—% and 61+% in the 3rd and 4th respectively, with a fairly level of course values of about 10% less for the remaining intervals. G. shows much the same thing; beginning with 57—% in the first interval and rising 67—% and 69% in the 3rd and 4th, with a rise and fall of lesser values to a minimum of 49+ in the 8th. W. begins with 37+% in the first interval and rises irregularly to 63—% in the 4th, and then has a course of values ranging between 56—% and 61—% in the remaining four intervals. In case of S., we have after the first two intervals, a fairly regular decline to 45+% in the eighth.

Comparing the two classes of wrong judgments with each other, we find in case of P. the percentage of wrong judgments on the whole higher for the "V ≶ N" or unlike, than for "VIIIN" or like, the opposite of this in case of G. but the same in case of W.

For $\triangle = 0$ we note the following results. With right judgments, which in this instance are "like," we have in case of P., the maximum of 50% in the third interval with a fairly regular decline during the remaining intervals to a minimum of 9+ in the 8th; in case of G., a maximum of 53—% in the third, and a fairly regular fall thereafter to 15—% in the 8th; in case of W., an irregular course, beginning with a maximum of 69—% in the 1st and falling to 31+% in the 2nd and again to 31+% in the 5th; in case of S. an irregular decline from 52+% in the 1st to 35+% in the 8th. The percentage of right judgments is on the whole less for $\triangle = 0$ than for $\triangle = \pm 25$ gm.

Of the two class of wrong judgments, the "V ⟩ N" show a higher percentage than the others in case of P. (37+% and 11—% respectively), about the same in case of G (33— and 33+ resp.), and a lower percentage in case of W (17 + and 37+ resp).

In the following table will be found the distribution of the percentage of right judgments for the different intervals of time among the "absolute," "mixed," and "direct" in case of P. and G.

From the above table we see that in case of P. for $\triangle = \pm 25$ gm., 57—% all right judgments are "absolute," *i. e.*, those in which comparison is mediated by verbal supplementation, while only 2—% are "direct," *i. e.*, those in which there is an evident reproduction of memorial images with little or no classification of the weights. Likewise for G., 60+% all right judgments are "absolute," while only 2+% are "direct."

Comparing the different time intervals, we find a fairly regular increase in the percentage of right judgments in case of P.

TABLE VII.

Percentage of Right Judgments for the different Intervals of Time in the "Absolute," "Mixed" and "Direct" classes.

t. i.		20	30	40	50	60	80	100	120	Total.
Dr. P.										
$\Delta = \pm$ 25 gm.										
Absolute,		40+	46—	51—	54—	58+	61—	69—	68—	57—
	No.	17	17	43	49	38	43	55	50	312
Mixed,		55—	49—	46—	44—	41+	39+	31+	32+	41—
	No.	23	18	39	40	27	28	25	24	224
Direct,		5—	5+	3+	2+	0	0	0	0	2—
	No.	2	2	3	2	0	0	0	0	9
$\Delta = 0$ g.										
Absolute,		38+	39+	41—	54+	61—	63—	61—	64+	51—
	No.	16	18	20	25	28	30	14	7	158
Mixed,		50	48—	43—	28+	33+	35—	35—	36—	39—
	No.	21	22	21	13	15	17	8	4	121
Direct,		12—	13+	16+	17+	6—	2+	4+	0	10+
	No.	5	6	8	8	3	1	1	0	32
Mr. G.										
$\Delta = \pm$ 25 gm.										
Absolute,		49—	52	50	51—	62+	69—	71—	79+	60+
	No.	22	26	32	42	29	46	51	42	290
Mixed,		44+	44	45+	47—	38+	31+	29+	21—	38—
	No.	20	22	29	39	18	21	21	11	181
Direct,		7—	4	5+	2+	0	0	0	0	2+
	No,	3	2	3	2	0	0	0	0	10
$\Delta = 0$										
Absolute,		47—	43—	43+	46+	48—	49—	57+	64—	48—
	No.	21	18	23	18	23	19	12	14	148
Mixed,		44+	48—	43+	36—	37+	38+	43—	36+	41+
	No.	20	20	23	14	18	15	9	8	127
Direct,		9—	9+	13+	18—	15—	13—	0	0	11+
	No.	4	4	7	7	7	5	0	0	34

from 40+% in the first interval to 68—% in the 8th. Further, the "direct" judgment are found only in the earlier intervals. So too with G., there is an increase from 49—% in the first to 79+% in the 8th, and as with P., the direct judgments are found in the earlier intervals.

For $\Delta = 0$, the general trend is the same. P.'s results show an increase from 38+% to 64+% in "absolute" judgments in going from 1st to 8th interval, with the greater part of the "direct" judgments in the earlier intervals. G. increases irregularly from 47% in the first interval to 64—% in the 8th in the absolute judgment, and has most of the direct judgments in the earlier intervals. Passing to the totals, we find

51—% of P.'s judgments "absolute" and only 10+% of them "direct," and 48—% of G.'s "absolute" and 11—% "direct."

The percentage totals for the eight intervals of time taken together, which are given below, present some very interesting results in respect to the distribution of right and wrong judgment within each class.

TABLE VIII.

Percentage Totals of the eight Intervals of Time taken together for the different classes and kinds of Judgment.

$\Delta = \pm$ 25 gm.

Re-agent.	Nature of Judgment.	Percentage of Right V ≷ N	Wrong. V ≶ N	Wrong. V VIII N	All judgments of each reagent.
Mr. G.	Absolute,	67—	18—	17+	53—
	No.	290	67	73	430
	Mixed,	56+	19—	25+	39+
	No.	181	59	81	321
	Direct,	16+	31+	53+	8—
	No.	10	19	32	61
Dr. P.	Absolute,	60—	24—	16+	49—
	No.	312	123	86	521
	Mixed,	43+	30+	27—	48+
	No.	224	157	137	518
	Direct,	32+	46+	22—	3—
	No.	9	13	6	28
Mr. W.	Absolute,	57+	32+	11—	79+
	No.	182	102	34	318
	Mixed,	56	28	16	12+
	No.	27	15	8	50
	Direct,	56+	19—	25—	8+
	No.	18	6	8	32
	Immediate,	1—			1—
	No.	2			2
Mr. S.	Absolute,	77—	23+		60—
	No.	96	29		125
	Mixed,	45+	54—		26+
	No.	25	40		55
	Direct,	33+	67—		14+
	No.	10	20		30

$\Delta = 0$ gm.

Re-agent.	Nature of Judgment.	Percentage of Right V VIII N	Wrong. V < N	Wrong. V > N	All judgments of each reagent.
Dr. P.	Absolute,	38—	30+	20+	43—
	No.	158	126	135	419
	Mixed,	27—	33—	40+	46+
	No.	121	148	184	453
	Direct,	30+	27—	43—	11—
	No.	32	28	45	105

TABLE VIII.—*Continued.*

Reagent.	Nature of Judgments.	Percentage of Right VIIIN	Wrong. V < N	Wrong. V > N	All judgments of each reagent.
Mr. G.	Absolute,	34—	35—	31+	49—
	No.	148	153	137	438
	Mixed,	36—	30+	34—	39—
	No.	127	106	116	350
	Direct,	30+	31—	39—	12+
	No.	34	35	44	113
Mr. G.	Absolute,	42—	42+	16	77—
	No.	148	150	58	356
	Mixed,	61+	22+	17—	15+
	No.	44	16	12	72
	Direct,	50	33+	17—	5+
	No.	12	8	4	24
	Immediate,	57+		43—	3+
	No.	8		6	14
Mr. S.	Absolute,	41—	59+		75+
	No.	75	110		185
	Mixed,	31—	69+		16—
	No.	12	27		39
	Direct,	45—	55+		9—
	No.	10	12		22

For the difference of ±25 gm. we find in case of P. 49—% of all his judgments are "absolute," 48+% "mixed," and only 3—% "direct;" in case of G., 53—% of all judgments are "absolute," 39+ "mixed" and but 8—% "direct;" in case of W., 79+% "absolute," 12+% "mixed," 8+% "direct;" in case of S. 60—% are absolute, 26+% "mixed," and 14+% "direct." The distribution of right and wrong judgments is this: for G., 67—% of all "absolute" judgments, 56+% of all "mixed" judgments, and 16+% of all "direct" judgments are right; for P., 60—% of all "absolute," 43+% of all "mixed," and 32+ of all "direct" judgments are right; for W., 57+% of all "absolute," 56% of all "mixed," 56+% of all "direct" judgments are right; in case of S., 77—% of all "absolute," 45+% of all "mixed," and 33+% of all direct are right.

The distribution of wrong judgments between the two classes of "like" (VIIIN) and "unlike" (V≷N), does not follow any law for the different reagents. P. has more "unlike" than "like;" G. has more "like" for "mixed" and "direct," and about the same number of "like" and "unlike" for absolute judgments. W. has more "unlike" for "absolute" and "mixed" and more "like" for direct judgments.

For $\Delta = 0$, we have the following percentages: 1st taking all the judgments of each reagent, P., 43—% "absolute," 46% "mixed" and only 11—% direct; G., 49—%, "absolute,"

39—% "mixed," and but 12+% direct; W., 77—% "absolute," 15+% "mixed," 5+, "direct," 3+% nondescript or immediate; S., 75+%, "absolute," 16—% "mixed" and 9—% "direct."

2nd. Taking the different kinds of judgments, P has 38–%, the "absolute" right, 27—% of the "mixed" right, and 30% "direct" right; G. has 34—% of the "absolute" right; 36+% the "mixed" right, and 30+% the "direct" right; W. has 42—% the "absolute" right, 61+% of the "mixed right," 50% of the "direct" right; S. has 41—% of the "absolute" right, 31—% of the "mixed" right and 45—% of the "direct" right.

3d. Of the two classes of wrong judgments, the percentage runs higher on the whole for "V ⟩ N" judgments in case of both P. and G., with the opposite relation for W. There are some miscellaneous facts related to the above which it is necessary to put into tabular form. The distinction of right judgments among the different kinds of judgments is as follows: $\Delta = \pm$ 25 gm., P. has 57+ "absolute," 41—% "mixed," and 2—% direct; G. has 60+% "absolute," 38—% "mixed" and 2+% direct; W. has 71+% absolute, 12—% "mixed" and 8—% "direct;" S. has 73+% "absolute," 19+% mixed and 8—% direct. For $\Delta = 0$ gm, 51+% of right judgments are "absolute," 39—% "mixed," 10+ "direct" in case of P.; 48% absolute, 41% "mixed" and 11% "direct" in case of G.; 70—% absolute, 21+% "mixed" 5+% "direct," and 4—% "immediate" in case of W.; 77+% "absolute," 12+% "mixed," 10+ "direct" in case of S.

Summary of Results.

1. The larger portion of the judgments are absolute, *i.e.*, those in which verbal supplementation is the most conspicuous part of the judgment process. This agrees with the conclusions reached by Prof. Angell in his experiments on the discrimination of shades of gray.[1]

2. There is a correlation between correctness of judgments, length of time in making the judgment, and the relative mean variation. There is a decrease in the length of the reaction, in the extent of the mean variation and an increase in the percentage of right judgments during the earlier intervals, clearly indicated in the case of the reagents, Dr. Pillsbury and Mr. Galloway, who have furnished over three-fourths of the judgments recorded. The interval of 40 to 60 secs. seems the most favorable for the judgments, so far as this is indicated by maximum percentage of right cases, minimum length of reaction time and mean variation. These results thus indicate some fundamental change in condition for judgments made with a longer interval between presentation of norm and comparison stimulus. Prof. Angell also found in the experiments above noted, that

[1] Philos. Stud., Vol. 19, p. 21.

the reaction was shortest for 60 secs., the longest interval investigated; and explains the fact as due to a change in sensory conditions. He writes in the article already referred to: "as regards the reactions for 5 secs. it has been observed that the demeanor of the reagents for the shorter intervals, is commonly, though not invariably, different from what it is in the longer In the 30 and 60 sec. intervals, the reagent is apt, soon after the exposure of the norm, to relax the trunk muscles, settle himself in an easy attitude, to breath easily and to move the eyes from time to time over the background. During the shorter periods, as has already been observed, the reagents usually try to maintain uniform sensory conditions for both norm and comparison; the tension sensation from trunk, respiration and eye muscles are kept constant in order apparently to make the conditions of comparison as much alike as possible. Accordingly we have, for most reagents, a much larger mass of background of sensation entering into the comparison of shorter intervals, and in all probability more genuine acts of comparison."[1] I have made no records touching on the demeanor of the reagents for the various intervals; but there is a fact reported in the preceding part of this paper, which confirms the statements made in the above quotation, viz., that the percentage of absolute judgments increases in the longer intervals, while the direct judgments are relatively most numerous in the shorter intervals.

3. "Like" judgments are of a negative character, that is, such as the reagents make when the criteria of the other judgments are absent. There is an uncertainty in making judgments of this sort, which shows itself especially in a lengthened reaction time and often in a higher mean variation.

4. Right judgments are, as a rule, shorter, less variable than wrong judgments, the more so when there is a difference between norm and stimulus of comparison.

5. Absolute judgments are shorter and less variable than other kinds, and the percentage of them increases in the longer intervals. Frequently the memorial image acts as disturbing factor, as is seen in the fact that in many instances the "mixed" judgments are longer than either the absolute or direct.

6. The images are, according to the introspective reports of the reagents, more visual, or at least as much so, as they are motile. The sensations aroused by lifting weights are a complex of visual and kinæsthetic elements, of which the visual function the more conspicuously in the judgment process. When this is direct, that is a comparison between the sensations peripherally aroused by the stimulus of comparison, and the memorial image of the norm.

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[1] Philos. Stud., Vol. XIX, p. 18.

7. There is an evident loss of sensory memory with the flow of time, if by that we mean a higher percentage of errors for the longer intervals of time (beyond 30 to 60 seconds) and a lengthened time of reaction.

8. The general trend of the results is that in judging the comparative magnitude of lifted weights, the most important thing concerned in the process is not a memorial image undergoing a progressive decay that bears a definite mathematical relation to the time as measured by the amount of work necessary to restore it to its former integrity.

Brief Statement of Theory of the Judgment of Lifted Weights.

All reagents reported the immediate disappearance from consciousness of the memorial image, when present, as soon as the lifting of the second weight began; so that a direct comparison between the memorial image and the sensations aroused by the second weight in a way at all analogous to the comparison of two peripherally aroused sensations occupying consciousness simultaneously or nearly so, was out of the question. Besides, in these cases where the reagents were unable to pass any judgment whatever, because the norm had been completely forgotten, it was found that the failure was invariably due to an inability to reproduce the verbal supplement of "light" "heavy," etc., which served to place the norm in a scale of weight values. The classification of the norm enables the reagent to adjust the muscles for the lifting of the second weights or stimulus of comparison to a degree determined by the intensity of the strain sensation resulting from the adjustment. If this adjustment is just sufficient to lift the second weight with the usual degree of ease and rapidity, the norm and stimulus are felt to be equal; if the adjustment more than suffices, the second weight flies up more quickly than usual, and seems lighter; on the other hand, if the adjustment is insufficient, the weight does not move, a fresh innervation is made, the feeling of effort is correspondingly great, and the stimulus of comparison seems heavier. The judgment results from changes in a complex of peripherally aroused sensations, and not from a comparison between a peripherally aroused sensation and a copy of the same in the form of a memorial image. This theory is substantially that of Müller and Schuman.[1] with the exception of the part played by the "motor" image, The impulse to adjustment is largely a verbal idea, which gives a position to the weight in a scale of values.

[1] Müller and Schuman, Pflüger's Archiv, für Physiologie, 1889, Vol. 45, pp. 55 ff. Martin and Müller, Zur Analyse der Unterschiedsempfindlichkeit, Experimentale Beiträge, J. A. Barth, Leipzig, 1899, pp. 206 ff.